

# CHANGES IN THE BLOOD IN PRIMARY MALARIA

BY

R. M. GORDON

(From the Sir Alfred Lewis Jones Research Laboratory, Freetown,  
Sierra Leone)

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The observations that follow were made in England on three patients suffering from general paralysis of the insane, all of whom were undergoing treatment by a first attack of malaria, induced as the result of the bites of anophelines infected with *Plasmodium vivax*; in these cases, therefore, it was possible to observe the blood changes that occurred in a patient suffering from an undoubted primary attack of malaria, the date of acquirement of which was known. So far as the writer is aware, all previously recorded examinations have reference to patients who may—or may not—have been suffering from a primary attack and whose exact date of infection was not known. Ross (1924) has drawn attention to the importance of such observations in cases of primary malaria; the present work had already been started when his letter was published, but an attempt has been made to investigate one of the problems suggested by him; that is to say, whether or not there is any noticeable reduction in the total number of red cells before the appearance of parasites in the peripheral blood.

The following were investigated:—

(1) *The total number of red cells per cubic millimetre of blood.* The counts were made in the usual manner with a Thoma-Zeiss haemocytometer, the second drop of blood from the finger being always examined; it will be noted that the results are expressed in the table to the nearest half-million; this is due to the fact that a previous series of counts on a normal individual appeared to show that half-a-million was the usual limit of working error.

(2) *The colour index.* A measured volume of the patients' blood was haemolysed in distilled water and compared with the same

volume of a normal individual's blood also in distilled water (the same control being used throughout) ; the percentage of haemoglobin was then compared with the red cell count taken at the same hour, and the result expressed as the colour index.

(3) *Ratio of infected to non-infected red cells.* An adjustable counting eye-piece was used and set to cover a field of forty erythrocytes ; one thousand two hundred and fifty such fields were examined and the number of infected red cells in each field noted. It was found that in an evenly-spread film the number of red cells in such relatively small fields remained very constant, as was shown by counting the actual number of red cells present in every thirtieth field and if necessary, re-adjusting the eye-piece.

As already stated, previous writers' figures are concerned with the blood changes occurring in patients whose incubation period is unknown and whose previous history as regards malaria is uncertain ; it seems unprofitable, therefore, to compare these figures with those considered in the present paper. It may, however, be mentioned that Mannaberg (1894) quotes a large number of figures, both from his own observations and from those of other writers, which show that the reduction in the red cells varies greatly in different cases, but that the haemoglobin reduction is almost always directly proportional to the fall in the erythrocyte count ; that is to say, it is of the simple anaemia type. More comparable figures may be had from animal experiments ; thus Ben-Harel (1923) infected twenty-three birds by intramuscular injection of *Proteosoma praecox* ; he divides the resultant malaria into three types, primary acute infections, extended irregular infections, benign infections. Amongst other observations he clearly demonstrates, by means of daily blood counts, that : (1) In all three types a definite reduction in the total number of red cells occurred during the incubation period ; (2) there was no further fall in the number of red cells after the disappearance of parasites from the circulation ; (3) in all cases in which the infection did not prove fatal, the parasites increased to a certain maximum concentration and then proceeded to fall in numbers at approximately the same rate as that at which they had previously increased. This fall was sometimes interrupted by a relapse, causing a sharp temporary rise.

As the present writer only observed three cases, it would be

CASE 1. Male. Aged 38.

Day of observation— 1 = day of infection. 2 = day after infection, etc.	1	4	7	9	12	13	14	16	18	20	22	23	24	26	28	30	32	34	36	38	51
Total number of red cells per c.mm., in millions, to the nearest half-million ... ..	5½	5½	5½	5½	5½	...	5½	5½	5	4½	4½	...	3½	4	4	4	4	4	4	4½	4½
Total number infected amongst 50,000 red cells examined ... ..	0	0	0	0	0	0	7	62	217	172	180	...	12	0	0	0	0	0	0	0	0
Colour index ... ..	1	1	1	1	1	...	1	1	0.9	0.9	0.9	...	1	1	1	1	0.9	0.9	...	0.9	1
Quinine ... ..	0	0	0	0	0	0	0	0	0	0	0	30 grs.	30 grs.	0	0	0	0	0	0	0	0

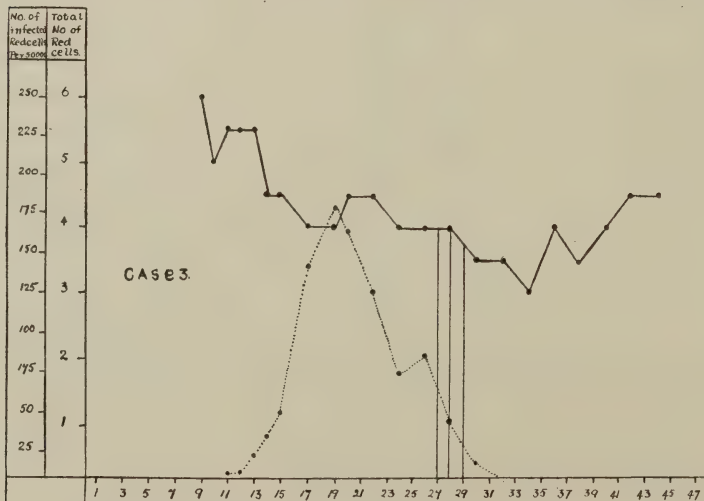
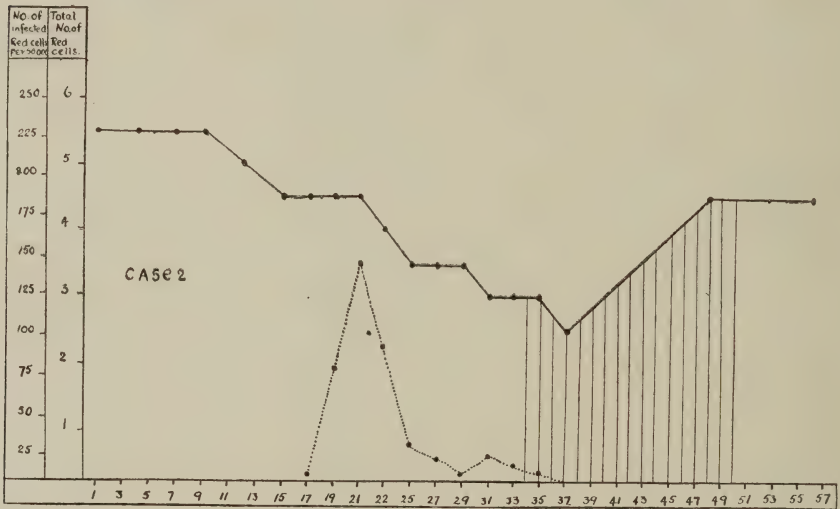
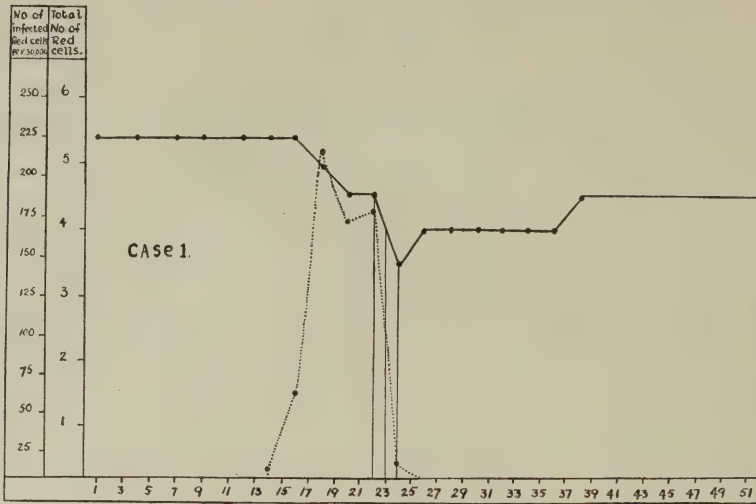
CASE 2. Female. Aged 13.

Day of observation— 1 = day of infection. 2 = day after infection, etc.	1	4	7	9	12	15	17	19	21	23	25	27	29	31	33	35	37	48	56
Total number of red cells per c.mm., in millions, to the nearest half-million ... ..	5½	5½	5½	5½	5	4½	4½	4½	4½	4	3½	3½	3½	3	3	3	2½	4½	4½
Total number infected amongst 50,000 red cells examined ...	0	0	0	0	0	0	8	80	146	94	33	24	8	25	14	7	0	0	0
Colour index ... ..	0.9	0.9	0.9	0.95	0.9	0.9	0.9	0.9	0.9	0.9	0.85	0.85	0.8	0.8	0.8	0.8	0.9	0.85	0.9
Quinine ... ..	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Quinine grs. 10 daily, from the 35th to the 50th day, inclusive.			0

CASE 3. Male. Aged 44.

Day of observation— 1 = day of infection. 2 = day after infection, etc.	9	10	11	12	13	14	15	17	19	20	22	24	26	28	29	30	32	34	36	38	40	42	44
Total number of red cells per c.mm., in millions, to the nearest half-million...	6	5	5½	5½	5½	4½	4½	4	4	4½	4½	4	4	4	...	3½	3½	3	4	3½	4	4½	4½
Total number infected amongst 50,000 red cells examined ... ..	0	0	2	4	23	30	51	143	178	165	125	75	85	43	...	14	0	0	0	0	0	0	0
Colour index ... ..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Quinine ... ..	0	0	0	0	0	0	0	0	0	0	0	0	0	30 grs.	30 grs.	0	0	0	0	0	0	0	0

Graphical records showing the results of blood examinations in three cases of primary malaria.



**Explanation of Table.** The dotted line represents the total number of infected red cells amongst fifty thousand examined. The continuous horizontal line represents the total number of red cells expressed in millions to the nearest half million. The vertical lines delimit days on which quinine was given, in cases one and three the amount given was thirty grains daily, in case two, ten grains daily. The base line shows the days on which observations were recorded: 1 being the day of infection, 2 the day after infection, etc.

unwise to draw any definite conclusions, but the following points appear to be of interest, especially when compared with Ben-Harel's corresponding figures for birds. (1) In case No. 2 there was a marked diminution in the number of red cells for several days previous to the first appearance of parasites, and the same, though in a less marked degree, is true of No. 3 case; on this particular point, therefore, these two cases accord with Ben-Harel's findings. (2) In at least one patient, the red cell count continued to fall after the disappearance of parasites from the peripheral circulation. This is contrary to all Ben-Harel's findings. (3) The parasites, after reaching a maximum concentration, on or about the fifth day after their first appearance, tended to diminish in numbers; this diminution was slower than the previous increase and took place whether quinine was given or not; it was clearly observable in all three cases, but most marked in cases two and three, in which the maximum concentration was in each case reached somewhere between fourteen and twenty thousand parasites to the cubic millimetre. On the whole, these figures correspond closely with those given by Ben-Harel under the title 'Acute primary infection,' although in some of his cases the parasitic concentration reached was far higher. (4) In two cases where the colour index was estimated it was found to be of the simple anaemia type.

#### REFERENCES

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